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Crack-resistant calcium aluminosilicate glasses

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The crack resistance of glasses is a crucial factor for their various applications. It is well known that the theoretical tensile strength of glass (up to 20 GPa) is significantly higher than its actual strength that is limited by defects and surface flaws. To understand the fracture behavior of glass it is important to reveal the relation between glass structure and crack resistance. There has recently been some progress in understanding such relation [1-3]. Crack-resistant glasses exhibit low elastic moduli, atomic packing density and Vickers hardness. In the present work, we report our findings about the mechanical behaviors of calcium aluminosilicate glasses fabricated by the aerodynamic levitation technique and traditional melt-quenching method. The link between crack-resistance and the densification and plastic flow has been investigated previously. Based on AFM measurements on indented glasses, we determine the densification and plastic deformation volumes before and after annealing around the glass transition temperature (T_g). We have found that some of calcium aluminosilicate glass compositions exhibit extraordinarily high crack resistance. We have revealed the structural origin of the high crack resistance by means of combined techniques such as calorimetry, viscometer, Raman spectroscopy, and nuclear magnetic resonance. In addition, we discuss the composition dependences of T_g , fragility, density, Vickers hardness and fracture toughness of calcium aluminosilicate glasses.

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